

High-Power THz Quantum-Cascade VECSEL based Local Oscillator, Phase I

Completed Technology Project (2018 - 2019)



Project Introduction

NASA and NASA funded missions/instruments such as Aura/MLS (Microwave Limb Sounder), SOFIA/upGREAT and STO/STO-2 have demonstrated the need for local oscillator (LO) sources between 30 and 300 μm (1 and 10 THz). For observations >2 THz, technologically mature microwave sources typically have microwatt power levels which are insufficient to act as LOs for a heterodyne receiver.

LongWave Photonics is proposing to develop a high power, phase/frequency-locked, single mode, THz QC-VECSEL quantum cascade laser (QC-VECSEL) system with >5 mW average power at 77K at 4.74 THz band. The system includes a THz QC-VECSEL gain chip based on metasurface gain structure with an integrated cavity adjustment structure. The VECSEL LO will be packaged in a high-reliability Stirling cycle cooler with modification to minimize vibration noise. The source will be frequency locked to a stable microwave reference with <100 kHz line width in Phase II.

Anticipated Benefits

NASA applications include the use of the QCL as an LO for >2 THz receivers for future missions. Here the narrow linewidth (<100 kHz) of the QC-VECSEL can be used to resolve Doppler-limited low-pressure gasses ($\sim\text{MHz}$ linewidth). The QC-VECSEL LO will be a compact replacement for any gas-laser LO. The resulting source will be a compact, reliable, table-top, frequency stabilized high power THz LO with high beam quality which can sufficiently pump multi-element HEB receiver array.

Initial applications are research markets for low-pressure gas spectroscopy. The narrow line width and the ability to provide real-time frequency information of THz radiation also has great appeal. For industrial applications, the use of high-reliability, compact Stirling coolers would increase the usability of these QC-VECSEL devices, which have traditionally required liquid nitrogen cooling or larger cryocooling systems.

LONGWAVE
PHOTONICS



THz QC-VECSEL

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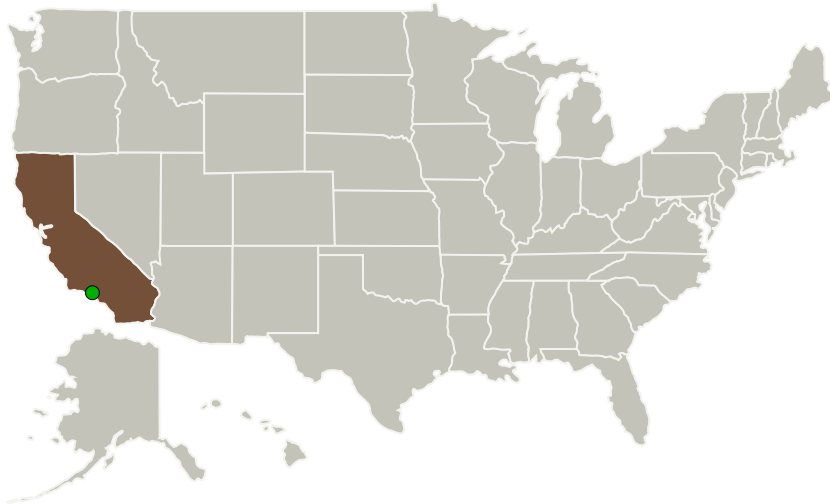
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
LongWave Photonics, LLC	Lead Organization	Industry	Mountain View, California
● Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations

California

Project Transitions

**July 2018:** Project Start**February 2019:** Closed out**Closeout Documentation:**

- Final Summary Chart(<https://techport.nasa.gov/file/141096>)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

LongWave Photonics, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

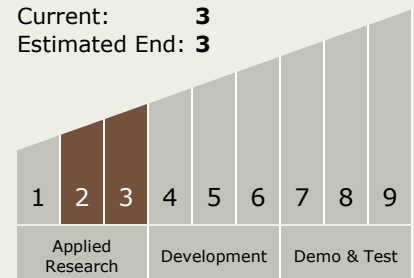
Carlos Torrez

Principal Investigator:

Tsongyu Kao

Technology Maturity (TRL)

Start: **2**
 Current: **3**
 Estimated End: **3**



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Images



Briefing Chart Image

High-Power THz Quantum-Cascade
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(<https://techport.nasa.gov/image/133402>)

Technology Areas

Primary:

- TX08 Sensors and Instruments
 - └ TX08.1 Remote Sensing Instruments/Sensors
 - └ TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destinations

Others Inside the Solar System,
Outside the Solar System